CE243B - DESIGN AND RESPONSE OF RC STRUCTURAL SYSTEMS

Problem Set #1: Dynamic Analysis – Response History/Spectrum

Due date: 1.1 and 1.2 April 9; 1.3 April 11

Problem 1.1 Response Spectrum Analysis

For preliminary design purposes, a 40 story, 480 ft tall, building with 12 ft story heights is modeled as a uniform shear beam. Therefore, the circular frequencies and mode shapes of the building are described as:

$$\omega_n = \frac{2n-1}{2}\pi\left(\frac{12\sum EI}{m_i h L^2}\right)$$

$$\phi_n(x) = \sin\frac{2n-1}{2}\left(\frac{\pi x}{L}\right)$$

where the values of story mass m_i = 24 kip-s^2/ft and total column stiffness at each floor $\sum$EI = 4.0E6 kip-ft^2.

Determine the following:

(a) The effective modal mass L_n^2 / M_n for each of the first five modes. What fraction of the total mass is associated with each mode?

(b) Compute the approximate maximum top displacement, base shear, and base over-turning moment by the root-sum-square method, assuming that the velocity response spectrum value for each mode is described by a UBC-97 equivalent code spectrum. Assume Seismic Source Type A (Table 16-U) with closest distance to known seismic source of 5 km (Tables 16-R, 16-S, 16-T). Soil conditions consist of a stiff soil with an average shear wave velocity of 800 ft/s. Assume ρ = 1.0, E_v = 0.0, and neglect Eq. 30-2 for E_m), and that the diaphragm is rigid.

Problem 1.2 Response Spectrum and Response History Analyses

A four-story building is modeled as a "stick-model", with a mass of 3 k-s^2/in. at each floor and 2 k-s^2/in. at the roof, and a story stiffness of 500 k/in. at all levels. Only one degree-of-freedom exists at each level, lateral translation (no joint rotation or axial deformation allowed). Use Matlab.

Determine the following:

(a) The roof displacement, base shear, and base over-turning moment histories for the NS component of the 1940 El Centro record. Assume Rayleigh damping (mass and stiffness proportional damping) with 5% damping in the first and third modes. Also compute the first mode contribution (history) for each of these quantities. Plot total and first mode response histories for each response quantity.

(b) Using the computed response spectrum for the NS component of the 1940 El Centro record, compute the peak quantities for the roof displacement, base shear, and base over-turning moment using the root-sum-square method. Assume 5% damping in all modes.

(c) Compare peak responses in (a) with estimates in (b).

Problem 1.3 Response Spectrum and Response History Analyses – SAP 2000

Redo problem 1.2 using SAP 2000.